Economy of Iron and Steel in Building Construction

Report of the Committee Constituted by the National Buildings Organisation

NATIONAL BUILDINGS ORGANISATION
October, 1957

BACKGROUND AND COMPOSITION OF THE COMMITTEE

Realising the imperative and urgent need for exploring all possible avenues leading to economy in the use of steel in building construction the Ministry of Works, Housing and Supply instructed the National Buildings Organisation in September, 1956 to constitute and convene a Technical Committee to examine and report on this matter. A Committee of the following was accordingly convened.

Chairman :

Sardar Sarup Singh
Director, National Buildings Organisation

Members :

Engineer-in-Chief, Army Headquarters
or his representative.[1]

Chief Engineer, Central P.W.D.
or his representative.[2]

Director, Civil Engineering, Railway Board
or his representative.

Housing Adviser, Ministry of Works,
Housing & Supply.

Indian Standards Institution.[3]

Ministry of Steel, Fuel and Mines.[4]

The first meeting of the Committee was held on 7th January, 1957. During the course of discussions it was felt that Shri R. N. Dutt, Deputy Controller of Iron and Steel and Shri C. J. Shah, Deputy Development Officer (Metals) may be co-opted as members of the Committee. In the penultimate meeting of the Committee held on 24th June Shri K. K. Nasta, Divisional Manager, State Trading Corporation was also present by special invitation to discuss some specific points that arose out of previous discussions.

The Committee held six meetings in all and discussed various aspects of the problem. The considered views of the Committee on the subject and its general and specific recommendations are set forth in this publication.

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1. Col. H.C. Vijh.
2. Shri M.S. Bhatia and Shri C.P. Malik
3. Shri T.V. Joseph, (Alternate : Shri C.S. Chandrasekhara).
4. Shri N. Padmanabha Iyer.

Observations and Recommendations of the Committee

The Committee realised that economy in the use of steel in buildings can be effected in several ways and concerted and co-ordinated drive is necessary on all possible fronts to obtain conspicuous results. Thus the saving may be through rationalisation of bye-laws and codes of practices, rationalisation of design methods, improvements in constructional practices and substitution by other suitable materials. Some of these measures, specially those of the last category, may be for a short duration i.e., for the period of emergency ; some others are for all times and can be brought into operation almost at once while others require a period of preparation, training and re-adjustment in thinking and in operations.

The Committee noted that the Indian Standards Institution have progressed substantially in rationalising bye-laws and codes of practices. Their past work and programme are well set out in their memorandum presented to the Government of India and Planning Commission in February, 1957 (*Appendix I*). The codes and standards so far finalised on this subject could be brought into use almost immediately, by all institutions and organisations. A specific recommendation to this end has been made in this report (*vide Recommendations 10 and 13*).

With the aid of these bye-laws and codes of practices the design methods will improve and will be rationalised. For design of steel structures, especially, the Indian Standards Institution have in hand preparation of handbooks covering the design and fabrication of almost all the types of structures.

In many places use of structural steel can be avoided by the use of M. S. bars or pre-stressing steel in concrete. Specific recommendations in this direction are given in *Recommendations 4 and 5* on *page* 5 of this report.

Design practices that result in economy in the use of structural steel include adoption of plastic design in place of elastic design currently adopted. Similarly it has been known that definite economies are associated with certain preferred shapes for sections and components.

To obtain the effective practical implementation of various aspects of efficiency in the use of steel in buildings there is a pressing need for a team of structural engineers. This need may be met either in the shape of a special cadre in Government Departments or in the shape of consultants in Government or private practice.

Foremost in the efforts to save steel through improvements of construction practices should come the use of superior construction materials and erection practices which bring in its wake the need for quality control. With this is connected a comparatively greater freedom for the administration to select efficient contractors especially for structures where large savings in steel (and cement) are possible through quality control.

The substitute materials, the Committee has in mind, are pre-stressed concrete, timber and non-ferrous metals like aluminium. The role of these materials in effecting economy in steel by their substitution has been taken into consideration while making *Recommendation 3* and the *Statement I* appended therewith. Partial pre-fabrication and mechanisation that are needed for large scale use of pre-stressed concrete have to be taken as the natural evolution in building construction techniques. These methods are even now in use though to a relatively smaller extent, for erection of structural steel.

With these thoughts in the background the Committee desires to place before the Government for their consideration the following recommendations.

Recommendation 1

The measures required to ameliorate the existing shortages in iron and steel materials, in so far as the building industry is concerned are partly technical and partly administrative and these should go hand in hand to produce useful results.

Further, such measures are either long term or immediate, permanent or temporary for the duration of this shortage (which as far as can be envisaged is likely to last for a considerable time). The immediate measures include adoption of higher stresses, more rational use and design of steel structures and use of substitute materials. The long-term measures include imparting training, encouraging better design practices and use of new techniques and materials.

Recommendation 2

The use of structural steel in building construction should be reduced to a minimum by its substitution by reinforced concrete and pre-stressed concrete and where possible and economical, by timber and aluminium where such substitute materials are available. Further re-inforced or pre-stressed concrete members should be efficiently designed to release maximum quantities of M.S. bars and rods and pre-stressing steel for use as substitute for structural steel.

Recommendation 3

Statement 1 (Page 11) indicates in broad terms the types of buildings and situations where steel of either category *viz.* structural or re-inforcing, may be used. These have to be adapted to circumstances obtaining in each region. The important point is that a competent technical authority should consider all these alternatives and adopt the one which is economical and suitable for the particular situation. The measures can be termed mostly administrative and partly technical.

Recommendation 4

Since M.S. rods and bars are the categories to be preferred to structurals from the foregoing considerations, the Ministry of steel Fuel and Mines and the Iron and Steel Controller should investigate the possibilities of turning out more M.S. rods and bars than at present, sacrificing, if necessary, equivalent quantities in the category of structurals.

Recommendation 5

(*i*) The need for substituting structural steel and ordinary reinforced concrete by pre-stressed concrete is vital in the present context of shortages of both cement and steel.

(*ii*) As a positive step towards this end it is necessary to ensure that adequate quantities of pre-stressing steel should be available in the country from which the intending consumers can draw without going through the time consuming procedure of importing their requirements for each individual use as is being done at present.

(*iii*) For this purpose it is considered necessary to stock some quantities of this material against anticipated demands.

(*iv*) The Government may constitute a Committee for the purpose of determining the quantity and specifications of the material, to be so stocked. This Committee may include the Consulting Engineer (Roads), the Engineer-in-Chief, Army Head-quarters, the Chief Engineer, Central P.W.D., the Ministry of Railways, Railway Board and representatives from State Governments who ordinarily use this material.

(*v*) The purchase, stocking and distribution of this material may be handled by the State Trading Corporation, a portion of the foreign exchange at present spent on the purchase of steel from abroad being diverted for this purpose.

(*vi*) The Committee referred to in para (iv) above will recommend the procedure to be adopted for allocation and distribution of this material to users against approved demands.

(*vii*) The present practice of permitting import of this material against *ad-hoc* indents should also continue and may even be liberalised to the maximum possible extent.

Recommendation 6

Timber is another substitute material proposed. Roofs of many buildings can be changed to timber construction. There is, however, an acute shortage of structural timber like teak ; secondary timber can be used for structural purposes provided they are seasoned and adequately treated. Facilities for such treatment are at present inadequate with the result that this change-over is rendered difficult. Steps should be taken to make available in the market adequate quantities of treated timber of secondary species for structural use. For this purpose a careful study, regionally, of the availability of timber (other than teak) should be made in collaboration with forest departments. If careful planning is done, the Committee feels, the change-over of roofing specifications to timber can be effected in a few years. These measures are technical and administrative.

Recommendation 7

To reduce dead weight in structures and consumption of steel, light weight construction is essential for multi-storeyed buildings. Hollow clay tiles and hollow concrete blocks with light-weight aggregates are suitable for this purpose. The

Committee considers that the Government should set up plants immediately for producing these materials in principal areas where multi-storeyed construction is coming into practice.*

These measures are mostly administrative and partly technical. If the materials are freely available economically, the technician will adapt his techniques to make use of them.

Recommendation 8

Use of Deformed Reinforcing Bars in Concrete effect considerable economy in M. S. re-inforcement. A note "Use of Deformed Reinforcing Bars in Concrete" prepared by N. B. O. will be found in *Appendix II.*

The Committee is informed that the Tata Iron and Steel Company is in a position to place these bars on the market at a nominal extra cost above the price of M. S. rods and bars. The Committee recommends that this may be done immediately and that these rods may be made available preferentially to M. S. rods and bars. The Government may inform concerned departments and State Government that this material should be used wherever possible taking advantage of the increased bond. These measures are partly technical but mostly administrative.

Recommendation 9

The Committee considers that there is room for economy in steel by its more rational use. This is amplified in the recommendations that follow.

Recommendation 10

The Committee has reason to suppose that live loads assumed for buildings of similar occupancies vary in the case of different departments. A fair measure of agreement has been reached in respect of loadings on structures in the draft Code IS : 875. The Government may advise all departments and State Governments to follow these standards as far as possible. This measure is technical.

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*The Chief Engineer, Central P.W.D. was of the view that the suitability of hollow clay tiles and concrete blocks with light weight aggregate should be examined further before setting up factories for their manufacture.

Recommendation 11

At present design of steel structures is generally being done on the basis of out-moded codes. The Indian Standards Institution's Code (I.S. 800-1956) is an improvement on this code in several respects. The Government may request and make it mandatory on all departments to follow this code with immediate effect. This measure though technical needs administrative backing.

Recommendation 12

It will be seen from the *Statement 1* (page 11) that where use of structural steel is unavoidable welding is preferred to rivetting from considerations of steel economy.

The Committee recommends that the Government may direct all departments that where structural steel is used, welded construction by competent welders should be accepted as an alternative and in preference to (if cost is the same for both) rivetted constructions.

For this purpose designs on recognised principles of plastic theory should also be accepted. The measure is technical but requires administrative backing.

Recommendation 13

The Committee considers that in order to inculcate in the authorities concerned a direct sense of responsibility in the matter of rational use of steel, it will be advisable if the officer approving the design, records in each major design, a certificate to the effect (i) that the use of structural steel has been avoided wherever possible and limited to the minimum in other cases and (ii) that the load stresses and design practices adopted are in conformity with I.S. 800-1956.

It is further considered that similar certificates from a Chartered Engineer may be insisted upon in respect of all designs in private sector in which substantial quantities of structural steel is released either by the Provincial Iron and Steel Controller or by the Ministry of Commerce and Industry.

Recommendation 14

The Committee considered a proposal that in the present context of acute steel shortage, the permissible stresses in

M.S. reinforcements in R.C.C. work may be increased ; the Committee recommends that this question may be referred to the concerned Committee of the Indian Standards Institution for their very early consideration and decision.

Recommendation 15

About one third of the quantity of M.S. rods and bars are at present marketted as un-tested. Permissible stress adopted for this category of steel by some departments is only 16,000 lbs. per square inch. Most of these rods are rolled from billets slightly falling short of the standard specifications. The Committee feels that the Iron and Steel Controller may arrange to market this steel as 'tested' but certified to a lower class, say Class II, with guaranteed physical properties. The permissible stress for reinforcing rods of this class shall be considered and laid down by the relevant Committee of the Indian Standards Institution.

Recommendation 16

The Committee observes that considerable economies in cost and in steel will arise out of rational design of foundations and structure. For this purpose the Committee recommends (1) that persons be specially trained as design engineers for structures and foundations and that (2) a specialist individual or body be created for consultations in matters arising out of design of steel and R.C.C. structures and foundations. The Committee further recommends that the National Buildings Organisation will be the appropriate body to contain these specialists. This measure is administrative in character.

Recommendation 17

The Committee has seen the preliminary study by the National Buildings Organisation regarding the consumption of cement and steel in 10 multi-storeyed buildings in Delhi and has noticed the wide variations in the use of materials. The Committee feels that most design authorities could keep target figures for use of steel for various types of buildings from analysis of buildings already designed, and the designers should see that these target figures are bettered every time. Periodical publication of such figures by a body like the National Buildings Organisation will be helpful in the sharing of such knowledge.

Recommendation 18

The Committee feels that the information on use of twisted steel made available to them was insufficient to arrive at firm conclusions and that more comprehensive information supported by test results may be collected before large scale use of this could be advocated. The National Buildings Organisation and the Central Building Research Institute will collaborate on this project.

STATEMENT 1

Recommendations regarding use or saving of reinforcing or structural steel in buildings of different types.* (*Also see Recommendation 3*).

Building component	Type of building	Recommended use in order of preference
Foundations	(*a*) Single-storeyed houses.	No steel is to be used.
	(*b*) Single-storeyed buildings for general purposes like schools, hospitals, office buildings etc.—usually less than 40′ span.	No steel is to be used.
	(*c*) Single-storeyed building for special purposes like large gowdowns, factories, workshops etc.—spans usually exceed 40′.	M. S. rods and bars as needed for footing of columns. Structural steel for grillages if unavoidable.
	(*d*) Multi-storeyed buildings for all purposes.	1. M. S. rods and bars for R.C.C. foundations. 2. Structural steel for grillages if unavoidable.

(*Contd.*)

These recommendations are applicable to non-seismic areas. In seismic areas M. S. reinforcements will be required in foundations, structures, roofs and partitions.

Similarly black cotton soil areas which present special foundation problems are excluded.

Building component	Type of building	Recommended use in order of preference
Load bearing structure—Walls-columns.	(*a*) Single-storeyed houses	1. No steel. All openings to be spanned by arches. 2. M. S. rods and bars for lintels if unavoidable.
	(*b*) Single-storeyed buildings for general purposes — spans usually less than 40′.	M. S. rods and bars for lintels only.
	(*c*) Single-storeyed buildings for special purposes— Spans usually exceed 40′.	1. No steel. Use masonry walls or pillars. M. S. rods and bars only for lintels. 2. M. S. rods and bars for R.C.C. columns (portal type), 3. Prestressing steel for columns. 4. Structural steel in columns with welded connections—portal type. 5. Structural steel with rivetted connection.
	(*d*) Multi-storeyed buildings for all purposes.	
	(*i*) For buildings up to 4 floors.	No steel-load bearing walls—M. S. rods and bars for lintels.
	(*ii*) For buildings up to 8 floors.	1. M. S. rods and bars for R.C.C. columns and lintels. 2. M. S. rods and bars and H.T. steel for prestressed concrete columns and lintels. 3. Structural steel. Columns with rigid connections to beams. M. S. rods and bars for lintels.

(*Contd.*)

Building component	Type of building	Recommended use in order of preference
		4. Structural steel columns with simply supported beam ends. M.S. rods and bars for lintels.
	(*iii*) For buildings above 8 floors.	1. M. S. rods and H. T. steel for prestressed columns. M. S. rods and bars for lintels. 2. Structural steel columns with rigid connections to beams. M. S. rods and bars for lintels. 3. Structural steel columns with simply supported beam ends. M. S. rods and bars for lintels.
Floors	(*a*) Single-storeyed houses.	No steel.
	(*b*) Single-storeyed buildings for general purposes–spans below 40′.	No steel.
	(*c*) Single-storeyed buildings for special purposes like large godowns, factories, workshops etc.–spans usually exceed 40′	1. M. S. rods and bars for foundations of machinery. 2. M. S. rods and bars for reinforcement of floors for special purposes only.
	(*d*) Multi-storeyed buildings for all purposes :	
	(*i*) Basement floor.	M. S. rods and bars for reinforcement of floor to resist hydro-static pressure when needed. (*Contd.*)

Building component	Type of building	Recommended use in order of preference
	(*ii*) Other floors.	1. M.S. rods and bars for reinforced concrete tee-beams in hollow block constructions and for solid R.C.C. slabs for W. C's., bathrooms and kitchens. 2. Constructions of the Madras terrace type requiring little or no reinforcement. M.S. rods and bars if the joists are of precast R.C.C. (Timber joists preferred) 3. M.S. rods and bars and high tensile steel for similar constructions as in (2) with prestressed concrete beams. 4. M.S. rods and bars for R.C.C. concrete slabs and beams (beams may be of R.C.C. or prestressed)
Roofs.	(*a*) Single-storeyed houses.	1. Hollow clay-tiles, natural stone-slabs etc., on timber joists requiring no steel. 2. Nails and bolts for timber trusses (minimum) of straps to be used by adopting modern designs). 3. M.S. rods, bars or high tensile steel for precast beams in place of timber beams in (2) above 4. M.S. rods, bars or high tensile steel for tee beams constructions with or without filler blocks.

(Contd.)

Building component	Type of building	Recommended use in order of preference
		5. M.S. rods or bars for straight R.C.C. slabs and beams construction.
	(*b*) Single-storeyed buildings for general purposes,— spans usually below 40′	
	(*i*) For spans up to 25′.	1. Nails and bolts for timber trusses (minimum straps to be used by adopting modern designs).
		2. Other items as in 4 and 5 in the under single-storeyed houses above sequence. (Roofing to be of asbestos, aluminium or G.I. sheets).
	(*ii*) For spans above 25′.	1. M.S. rods, bars or high tensile steel for tee-beams constructions with or without filler blocks.
		2. M.S. rods, bars and high tensile steel for R.C.C. beams and slabs.
		3. High tensile steel for prestressed beams with sheeted roofing of asbestos sheet or aluminium.
		4. Steel tubes and cold framed light gauge sections.
		5. Welded steel structural in portal construction with sheeted roofing of asbestos sheet or aluminium.

(*Contd.*)

Building component	Type of building	Recommended use in order of preference
		6. Welded steel structurals in roof trusses with sheeted materials as above.
		7. Rivetted steel structurals in trusses with sheeted materials
	(c) Single-storeyed buildings for special purposes like large godowns, factories, workshops etc.	1. M.S. rods and bars for use in shell construction
		2. M.S. rods and bars and high tensile steel for prestressed concrete beams and hollow block construction.
		3. M.S. rods and bars and H.T. steel for prestressed or R.C.C. portals with sheeted roofings of asbestos or aluminium.
		4. M.S. rods and bars for R.C.C. beams and slabs.
		5. Steel tubes and cold formed light gauge sections.
		6. M.S. rods and bars in concrete trusses with sheeted roofing asbestos or aluminium.
		7. Steel structurals, welded in portal frame construction with sheeted roofing.
		8. Steel structurals in welded trusses with sheeted roofing.
		9. Steel structurals in rivetted trusses with sheeted roofing. *(Contd.)*

Building component	Type of building	Recommended use in order of preference
	(*d*) Multi-storeyed buildings for all purposes	All specifications given under item 2 or 3 of column 2 depending on the free span
Windows.	(*a*) Single - storeyed houses.	No steel windows.
	(*b*) Single-storeyed buildings for general purposes.	Timber and in rare cases aluminium windows,
	(*c*) Single-storeyed buildings for special purposes.	1. Timber windows—no steel. 2. Aluminium windows—no steel. 3. Steel windows.
	(*d*) Multi-storeyed buildings for all purposes.	1. Timber windows—no steel. 2. Aluminium windows—no steel. 3. Steel windows.
Partitions.	(*a*) Single-storeyed houses.	No steel except for lintels where unavoidable.
	(*b*) Single-storeyed buildings for general purposes.	-do-
	(*c*) Single-storeyed buildings for special purposes.	1. No steel except for lintels where unavoidable.

(*Contd.*)

Building component	Type of building	Recommended use in order of preference
		2. Vertical supports for sheeted partitions to be of timber or R.C.C. or aluminium or lastly structural steel.
		3. Floor runners to be of timber or R.C.C. M.S. rods and minimum steel for connections.
		4. Ceiling runners to be of timber or aluminium ; steel is last preference.
		5. Capping runners for dwarf partitions be of light gauge steel where unavoidable.
	(d) Multi-storeyed buildings for all purposes.	As in the case of item 3 in column 2. Dwarf partitions rarely needed.
Miscellaneous items		
1. *Holdfasts*	For all buildings.	
	(*a*) For external doors.	13″ × 1″ × $\frac{1}{8}$″= 6 Nos. for doors and 4 Nos. for windows.
	(*b*) For internal doors :	
	(*i*) for walls of 9″ thickness and less.	As above.
	(*ii*) For walls exceeding 9″ thick.	No metal hold-fasts. Fixing by timber battens nailed on to frames in grooves in jambs.
2. ***Frames for doors and windows.***	For all buildings.	No R.C. frames should be used.

Appendix - I

REPORT ON THE STEEL ECONOMY PROGRAMME

(Up to December 31, 1956)

Presented by the

STRUCTURAL STEEL SECTIONAL COMMITTEE

INDIAN STANDARDS INSTITUTION
19, UNIVERSITY ROAD, CIVIL LINES
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INDIAN STANDARDS INSTITUTION

REPORT ON THE STEEL ECONOMY PROGRAMME

(Up to December 31, 1956)

1. Preliminary Planning

1.1 In 1950, the Planning Commission recommended to the Government of India that the Indian Standards Institution should undertake a programme for increasing efficiency in the use of structural steel, by the formulation and implementation of standards relating to its production and use. Accepting this recommendation, the Government of India requested the ISI to take up a Steel Economy Programme to include :

(*a*) Formulation of Standards for Hot-rolled sections ;

(*b*) Formulation of Standards for Cold-formed Light-gauge sections ;

(*c*) Formulation of Codes of Practice for the Use of Steel in Structures ;

(*d*) Preparation of Typical Designs and Drawings for and other aids to the implementation of the higher efficiency standards ;

(*e*) Preparation of Standard Specifications, Codes of Practice and other publications for popularizing welding as a medium of fabrication of steel ; and

(*f*) Sponsoring experimental and other investigations necessary for the formulation and revision of higher efficiency standards, relating to production and use of structural steel.

1.2 In the ISI, this work was entrusted to the Structural Steel Sectional Committee, BDC 7, under the Chairmanship of Sir Jehangir Ghandy. The composition of Sectional Committee BDC 7, is given as *Annexure I* (page 36).

1.3 The detailed work on steel economy could be initiated in the Directorate only from December 1953 since it took some time to arrange for the services of a suitable senior engineer to take charge of the Steel Economy Section. At the end of November 1953, Shri T. V. Joseph joined the ISI as the Officer on Special Duty. His services had been made available by the Ministry of Railways.

1.4 Shortly afterwards, the United States Technical Co-operation Mission in India finalized an agreement for technical assistance to the ISI for the Steel Economy Programme.

2. Inauguration of Work

2.1 The work of the Structural Steel Sectional Committee, BDC 7, was inaugurated by Shri T. T. Krishnamachari at Calcutta, on 13th February 1954. Shri T. T. Krishnamachari referred to the importance which the Government of India attached to the tasks allotted to the ISI under the Steel Economy Programme. He mentioned that the experts who had studied the problem of conservation of steel had estimated that more than 25 per cent of steel now used in structural engineering might be considered as wasted because of the use of un-economic sections and the adoption of un-economic and outmoded design practices. He pointed out that even with the restricted availability and use of steel in 1954, this wastage amounted to over 1,50,000 tons annually, costing the country 8 to 9 crores of rupees, on the basis of the value of imported steel. Stressing the urgency of the work initiated, he said that the iron and steel control organization of the Government of India would be helpful at a later stage in implementing the standards and other findings of the Committee and that, if necessary, the enforcing of these recommendations could be arranged through Government regulations.

3. First Meeting of the Steel Economy Committee of the ISI

3.1 The first meeting of the Committee was held on 13th February, 1954 under the Chairmanship of Sir Jehangir Ghandy.

3.2 The Structural Steel Sectional Committee, BDC 7, at its first meeting, distributed the steel economy work to four sub-committees, namely :

(*i*) Steel Sections Sub-committee (BDC 7 : 1) ;

(*ii*) Structural Codes and Design Sub-committee (BDC 7 : 2) ;

(*iii*) Welding Sub-committee (BDC 7 : 3) ; and

(*iv*) Structural Steel Research Sub-committee (BDC 7 : 4)

3.3 The four sub-committees, in turn, had to set up a number of panels, to cover effectively the wide variety and extent of the subjects allotted to them. The names of the conveners of the four sub-committees and of the various panels set up by them are given in *Annexure II* (page 39).

3.4 The Steel Sections Sub-committee (BDC 7 : 1) is responsible for the formulation of standards for and the preparation of a handbook of structural sections. The Structural Codes and Design Sub-committee (BDC 7 : 2) is responsible for the formulation of codes of practice for the use of steel in structures and for the preparation of handbooks, typical designs, etc., for structural engineers. The Welding Sub-commitee (BDC 7 : 3) is responsible for the formulation of specifications and codes of practice relating to welding and for the preparation of handbooks, brochures, etc, for the use of welding-engineers, inspectors, supervisors, and welders. The Structural Steel Research Sub-committee (BDC 7 : 4) is responsible for co-ordinating and sponsoring experimental research and also for the formulation of specifications relating to corrosion protection of light-gauge structural steel work.

4. Second Meeting of the Structural Steel Sectional Committee (BDC 7)

4.1 The second meeting of the Sectional Committee BDC 7 was held on 5th May 1955 at Calcutta under the Chairmanship of Sir Jehangir Ghandy.

4.2 In this meeting the Sectional Committee approved the detailed programmes of work prepared by the Sub-committees and also the issue for wide circulation and comments, of the Draft Indian Standards on

(*a*) Code of Practice for Use of Steel in General Building Construction ;

(*b*) Scheme of Symbols for Welding ;

(*c*) Code of Practice for Use of Metal Arc Welding for General Construction in Mild Steel ;

(*d*) Glossary of Terms Relating to Welding and Cutting of Metals ;

(*e*) Specification for Covered Electrodes for Metal Arc Welding of Mild Steel ;

(*f*) Classification of Covered Electrodes for Metal Arc Welding of Mild Steel and of Low Alloy High Tensile Steels of Welding Quality ; and

(*g*) Code of Practice for Training and Testing Metal Arc Welders.

4.2.1 These seven draft Indian standards were later on finalized by the Committee through correspondence.

4.3 The Committee also considered the subject of 'tested' and 'untested' steels and decided that 'untested' steel should more appropriately be designated as 'commercial quality steel', and recommended to the Basic Ferrous Metal Sectional Committee (EDC 3) of the Engineering Division Council (EDC) of the ISI the formulation of one or more additional specification to cover these steels, in addition to IS : 226-1955 Specification for Structural Steel.

5. Third Meeting of the Structural Steel Sectional Committee (BDC 7)

5.1 This meeting was held at Delhi on 13th December, 1956, under the Chairmanship of Sir Jehangir Ghandy.

5.2 In this meeting, the Sectional Committee finalized for publication, the Indian standards mentioned below :

(*a*) Specification for Rolled Steel Sections—Beams ;

(*b*) Specification for Rolled Steel Sections—Channels ;

(*c*) Specification for Rolled Steel Sections—Angles ;

(*d*) Code of Practice for Safety and Health Requirements in Electric and Gas Welding and Cutting Operations ; and

(*e*) Code of Practice for Resistance Spot Welding for Light Assemblies in Mild Steel.

5.3 The Committee also approved of the issue for wide circulation and comments, the Draft Indian Standard Specifications for

(*a*) Rolled Steel Sections—Tee Bars ; and

(*b*) Rolled Steel Sections—Bulb Angles.

6. Formulation of Standard Specifications and Codes of Practice

6.1 Details of the specifications and codes of practice on which work was undertaken as a part of the Steel Economy Programme are given below :

Standards for Structural Sections

(*a*) Rolled Steel Beams ;

(*b*) Rolled Steel Channels ;

(*c*) Rolled Steel Angles ;

(*d*) Rolled Steel Tee Bars ;

(*e*) Rolled Steel—Bulb Angles

(*f*) Tubular Sections ;

(*g*) Cold Formed Light Gauge Steel Sections ;

(*h*) Special Steel Sections for Structural Use ; and

(*i*) Rolled Steel Piling Sections.

Design Codes

(*a*) Code of Practice for Use of Structural Steel in General Building Construction ;

(*b*) Code of Practice for Use of Cold Formed Light Gauge Sections in Structures ;

(*c*) Rules for the Design, Construction, Erection, Testing, Operation, Maintenance and Inspection of Cranes and Hoists ;

(*d*) Code of Practice for Pressed Steel Tanks ;

(*e*) Code of Practice for Design, Fabrication and Erection of Mild Steel Tanks for Storage of Oil ;

(*f*) Code of Practice for Design, Fabrication and Erection of Steel Tanks ; Standpipes, Reservoirs and Elevated Tanks for Water Storage ;

(*g*) Code of Practice for Gas Storage Tanks ;

(*h*) Code of Practice for Use of Steel Tubes in General Building Construction ;

(*j*) Code of Practice for High Strength Bolting in Structures ;

(*k*) Code of Practice for Light Weight Open Web Steel Joist Construction ;

(*m*) Code of Practice for Use of Steel in Overhead Transmission Line Towers ;

(*n*) Code of Practice for Use of Steel in Radio Masts ; and

(*p*) Code of Practice for Use of Steel in Temporary Construction.

Welding Codes and Standards

(*a*) Glossary of Terms Relating to Welding and Cutting of Metals ;

(*b*) Scheme of Symbols for Welding ;

(*c*) Specification for Covered Electrodes for Metal Arc Welding of Mild Steel ;

(*d*) Classification and Coding of Covered Electrodes for Metal Arc Welding of Mild Steel and of Low Alloy High Tensile Steels ;

(*e*) Code of Practice for Use of Metal Arc Welding for General Construction in Mild Steel ;

(*f*) Code of Practice for Training and Testing of Metal Arc Welders ;

(*g*) Code of Practice for Safety and Health Requirements in Electric and Gas Welding and Cutting Operations ;

(*h*) Code of Practice for Resistance Spot Welding for Light Assemblies in Mild Steel ;

(*j*) Code of Practice for Use of Welding in Weldments (built-up sections for use in place of steel castings) ;

(*k*) Code of Practice for Use of Welding in Boilers ;

(*m*) Code of Practice for Use of Gas Welding in Structural Work ;

(*n*) Code of Practice for Use of Welding in Structures Subject to Dynamic Loading—Bridges ;

(*p*) Procedure Code for Electric Arc Welding ;

(*q*) Code of Practice for Inspection of Welds ;

(*r*) Code of Practice for Use of Welding in Pipelines ;

(*s*) Code of Practice for Resistance Steam Welding for Light Gauge Sections ; and

(*t*) Code of Practice for Use of Welding in Tubular Construction.

Standards for Corrosion Protection

(*a*) Specification for Corrosion Protection of Light Gauge Construction ; and

(*b*) Specification for Performance Tests for Protective Scheme Used in Corrosion Protection of Light Gauge Steel.

The position as on 31st December 1956 regarding the progress of these standards is given in *Annexure III* (Page 42).

7. Handbooks and Other Aids for the Implementation of Standards

7. (*i*) Preparation of handbooks and other publications mentioned below form an important part of the ISI's work on Steel Economy :

(*a*) Handbook of Properties of Structural Steel Sections

  (*i*) Properties and Dimensions of Structural Shapes for Designing and Detailing ;

  (*ii*) Rolling Mill Practices ;

  (*iii*) Miscellaneous Data for Estimating and Designing ;

  (*iv*) Estimating and Detailing Information ;

  (*v*) Allowable Loads on Rivets, Bolts and Connections ; and

  (*vi*) Miscellaneous Data and Mathematical Tables.

(*b*) Handbook for Structural Engineers (Including Typical Designs and Drawings)

  (*i*) Functions of Good Design in Steel Economy ;

  (*ii*) Economy of Steel through Choice of Fabrication Methods ;

  (*iii*) Choice of Materials and Steel Economy Programme ;

  (*iv*) Steel Beams and Plate Girders ;

  (*v*) Steel Columns and Struts ;

  (*vi*) Roof Trusses in Steel ;

  (*vii*) Design of Welded Connections ;

  (*viii*) Single Storey Industrial and Mill Type Buildings in Steel ;

  (*ix*) Multi-storeyed Steel Framed Structures for Offices and Residences ;

  (*x*) Steel Transmission Towers ;

  (*xi*) Steel Work in Cranes and Hoists ;

  (*xii*) Large Span-Shed Type Buildings in Steel ;

  (*xiii*) Design of Storage Tanks ;

  (*xiv*) Design of Bunkers ;

  (*xv*) Use of Tubes as a Structural Material ;

  (*xvi*) Structural Use of Light Gauge Sections ;

(*xvii*) High Strength Bolting in Steel Structures ;

(*xviii*) Lightweight Open Web Steel Joist Construction ;

(*xix*) Design of Rigid Frame Structures in Steel ;

(*xx*) Application of Plastic Theory in Design of Steel Structures; and

(*xxi*) Commentary on the Code of Practice for Use of Structural Steel in General Building Construction.

(*c*) Handbook for Welders.

(*d*) Handbook for Welding Inspectors and Supervisors.

(*e*) Handbook for Welding Engineers Typical Designs and Drawings,

Progress of this work as on 31st December 1956, is indicated in *Annexure III* (Page 42).

8. Experimental Investigations

8. (*i*) During the course of their work on various standard specifications and codes of practice, the committees entrusted with the steel economy work came across a number of problems on which data are not available or are incomplete. Such items, after scrutiny by the Sub-committee BDC 7 : 4 and the Sectional Committee BDC 7, were submitted to the Council of Scientific and Industrial Research with the request that financial and other assistance, as was required for arranging these investigations, may be made available. Various institutions in India were approached in connection with the investigations, and the items as included in *Annexure IV* (Page 45) have so far been allotted to the Institutions mentioned against them.

8. (*ii*) At a meeting held on 22nd September 1956, the Board of Engineering Research of the Council of Scientific and Industrial Research, accepted and allotted to the National Physical Laboratory, an extensive programme of investigations relating to the production and use of cold-formed light-gauge structural sections.

8. (*iii*) In consultation with the Government Test House, the Directorate of Research of the Ministry of Railways, and the Technical Development Establishment Laboratories, Kanpur, details of an extensive programme relating to corrosion protection of steel structures with particular reference to light-gauge steel are being worked out. This programme includes investigations required in connection with the classification of areas in India on the basis of corrosiveness.

9. Certain Important Aspects of the Steel Economy Programme

9.1 *Hot Rolled Steel Sections* : Early in 1954, when the work on the redesign and standardization of hot rolled steel structural sections was initiated, production of structural sections in India was mainly through two organisations, namely, the Tata Iron & Steel Co. Ltd. (TISCO) and the Indian Iron & Steel Co. Ltd. (IISCO). The programme at that time was, therefore, confined to the redesign of the limited variety of sections producable with the existing equipment at these two factories. The decision of Government to set up the Hindustan Steel Ltd., at Rourkela, did not necessitate any change in this programme since the production of that company was to be confined to flat products. In early 1955, however, it came to the notice of the committees that plans for the installation of two new factories, one at Bhillai and the other at Durgapur, were also being considered and it was possible to arrange for the production of a wider range of structural sections through them. TISCO and IISCO had also decided on large expansion programmes, including additional mills and improvements to existing ones. Shortly afterwards, came the decision of the Government about the change over to the metric system. These developments necessitated a complete re-orientation of the work on standardization of hot-rolled sections. It also became possible for the Indian Standards to cover more effectively the wide field of requirements of steel sections through the provision of a number of types of beams and channels of both lighter and heavier proportions.

9.1.1 *Higher Efficiency Sections*—In the case of beams and channels, the new sections being standardized give increased efficiency of 5 to 15 per cent when compared to the sections rolled hitherto in India. The new Indian Standard sections compare favourably with those of other countries and, in most cases, are an improvement on them. In the case of Angles, Tees, etc., the new standards have achieved rationalization without affecting economy in use. All the structural sections are standardized in the metric system.

9.1.2 *Co-ordination with the Commission Mixte des Aciers (CMA) and the European Coal & Steel Community (CECA)*—Early in 1955, it came to the notice of the ISI that on the initiative of the Commission Mixte des Aciers (CMA) of Bilguime Luxembourg, the countries of the European Coal and Steel Community (CECA), had launched a scheme of re-design and standardization of hot-rolled structural sections. Since the aim of this scheme was the same as that of the ISI, as regards redesign of structural sections, exchange of information between the ISI and the CMA and the CECA, has been maintained. It is gratifying to note that the steps along which the work of the CMA and CECA has developed, closely follow the steps taken by the ISI committees.

9.2. *Basic Design Code*—The basic code for the use of steel in general building construction is now under print. In this code, the committees have tried to prescribe for India, standards in line with present day developments and practices generally accepted in other countries. The increased efficiency in use of steel available through the adoption of this code varies from organization to organization depending on the practices so far adopted by them. In a few cases where the present practices are largely modern in approach, the advantages would be small. But, in the large number of cases where out-dated and unduly conservative design practices have so far prevailed, the adoption of the Indian Standard Code could yield considerable savings in steel.

9.3 *Welding*—Before the use of weldings can be increased, it is vital that the quality and dependability of welded designs and welding should be improved. Specifications and design codes alone were considered as insufficient to improve these aspects and to create greater confidence in welding. The handbooks for welders, inspectors, supervisors, etc., however, are expected to be of great help in this connection.

9.4 *Interest in Other Countries of the Commonwealth*—At the 1951 meeting of representatives of the National Standards Bodies of the Commonwealth Countries, considerable interest was shown in the Steel Economy Programme which the ISI was proposing to launch. The Commonwealth countries have, therefore, been kept informed of the developments of this programme. At the Commonwealth Standards Conference, to be held in Delhi in January—February 1957, a technical session is to be devoted to the discussion of various aspects of the Steel Economy Programme.

9.5 *Interest in Latin American Countries*—The Steel Economy Programme of the ISI has been of particular interest to the countries of Latin America whose industrial developments and problems are in many respects, similar to ours. At the request of the Economic Commission for Latin America (ECLA), the ISI presented, at the meeting of Experts on the Steel Making and Transforming Industries held at Sao Paulo, Brazil, from 15th to 28th October 1956, a detailed paper on ISI's work on standardization in the production and use of rolled steel sections in India. The ISI paper was presented during the integration discussions on October 25th. Since conditions in most Latin American countries parallel those which exist in India (viz, a relatively small steel industry, large excess demand, limited foreign exchange, active economic development efforts, etc), the paper was of immediate and direct interest to them. Furthermore, it provided an indication of what might be done as a partial answer to the existing and anticipated future steel shortage. There was considerable discussion following its presentation. At the end of the discussion, the meeting passed a resolution to establish steel economy programmes within the various Latin American countries under a joint committee to be set up by ECLA.

10. Implementation

10.1 *General*—As mentioned earlier in this report, the Steel Economy Programme of the ISI includes the preparation of not only standard specifications and codes of practice but also of handbooks and other publications as aids to implementation. The effectiveness of the Steel Economy Programme, in terms of actual savings in material and money would depend on the extent to which the practical aspects of the implementation could be followed up. The following paragraphs bring out certain of these aspects.

10.1.1 A co-ordinated plan for the works-cum-field implementation of the Steel Economy Programme has to be formulated and worked. The Government of India and the Planning Commission may consider the setting up of a suitable Body with powers to co-ordinate and effect this implementation. The Structural & Metals Division Council (SMDC) and the committees of the ISI responsible for the formulation of the standards, procedures etc., which are to be implemented, should be closely associated with this Body.

10.2 *Hot-rolled Sections*—The implementation of the Indian Standards for Hot-rolled Sections, does not present any serious difficulties. TISCO in their new mill and the steel mills at Bhillai & Durgapur, are expected to start production with the Indian Standard sections. In the preparation of the standards for sections, the capabilities and limitations of these mills have been particularly kept in view. As regards the existing mills of TISCO, IISCO & Mysore, the change-over to new sections would be on a programme phased over a period of time.

10.3 *Cold-formed Light-gauge Sections*—For production of cold formed light-gauge sections, strip steel of properties and widths covering the full requirements would become available in India only after production starts at Rourkela in 1958. Hot rolled strip up to $12\frac{1}{2}$ in. in width will be available from the Tata Iron & Steel Co., Ltd., if sufficient orders for structural quality material are placed. The immediate implementation of the standards for cold-formed sections, therefore, depends on the imported strip being made available and subsidized to the same extent as mild steel of other categories. It should be possible to give an impetus to the setting up of production units for the manufacture of cold-formed sections through encouragement by Government by way of loans etc., and also through consuming departments of the Central and State Governments accepting tenders for structures made from cold-formed sections, on a competitive basis, as compared to structures made from hot-rolled sections. The savings in steel through use of cold-formed light-gauge sections in certain structures will be as large as 40 per cent. By using strip steel from indigenous production or imported strip subsidized to the same extent as imported mild steel, there will be appreciable savings in overall cost also.

10.4 *Steel Tubes*—It is understood that the indigenous capacity for steel tubes up to 3 in. diameter leaves a surplus which could be diverted for structural use and further that the indigenous production of tubes up to 6 in. diameter is expected to start shortly. With the same type of encouragement as mentioned in para 10.3 above, it should be possible to popularize the use of steel tubes as a structural material.

10.5 *Efficient Designs*—The wide scale adoption in India of IS : 800-1956 Code of Practice for Use of Steel in General Building Construction, would lead to considerable savings in steel. Since the Central and State Governments have to set the pace in this connection, their co-operation is essential. With this co-operation, there is no doubt that the private agencies would also accept this code for their design offices.

10.5.1 The extent to which a code of practice could lead to a satisfactory design, greatly depends on the care and effort applied in the preparation of designs using the code. It is a matter of general opinion that there is considerable scope for improving the standard of design procedures in most organizations A possible method by which this may be achieved is through a technical check on demands for steel to see that they are based on efficient and economic designs. This check may be enforced at the organizational level and, in some cases, also by the Iron and Steel Controller.

10.6 *'Untested Steel'*—An appreciable tonnage of stee meant for structural purposes goes, at present, under the category of 'untested steel'. Since the strength property of this steel is not guaranteed or definitely known, it is not possible to use this steel efficiently by allowing stresses and loads to the maximum safe limits. The Structural Steel Sectional Commitee (BDC 7), has recommended that a separate standard should be drawn up for 'Commercial' quality steels which, even though not up to the requirements of the normal 'tested' quality steels, are usable, provided their physical and chemical properties are known and guaranteed.

10.6.1 Apart from this, consideration deserves to be given as to how far it is possible to reduce the tonnage of steel which has to be classified as not coming up to the present standards for Structural Steel.

10.7 *Welding*—There is already in India, a growing appreciation of the advantages which welding could afford in many cases of structural steel fabrication. But the natural reluctance of established fabricators to change over from riveted to welded fabrication procedures is even now acting as a retarding factor on this progress. An increased insistence by Government Organisations for welded fabrication could improve the situation. Apart from this, new fabricating organizations springing up in the private and public sectors, should be encouraged to set apart an appreciable proportion of their capacity for welded fabrication.

10.7.1. In order to implement the standards for welding and for popularising welding in India, it is also necessary that

(*a*) The Government should help in making available more freely suitable wire for the manufacture of electrodes in this country ;

(*b*) As transformers suitable for welding sets are not produced in India at present, the import of such tranformer welding sets should be permitted freely and the import duty on such transformer sets should be reduced in order to make them available more cheaply ;

(*c*) The import of oxygen cutting equipment should also be permitted freely and the import duty on such equipment should be reduced in order to make available in the country equipments of satisfactory quality at reasonable prices ;

(*d*) Technical institutions and universities in India should expand the facilities for the training of welding engineers, who would have a sound knowledge of both practical and theoretical aspects of welding ; and

(*e*) Basic trade schools and other facilities for training welders should be established in various parts of the country. The procedure and syllabus for training and testing welders should be in accordance with the Indian Standard on the subject. The certification of welders should be arranged through a centrally-controlled organization.

10.8 *Research*—Inspite of the fact that the CSIR had extended its full support to the whole programme of research drawn-up by the Structural Steel Research Sub-committee (BDC 7 : 4), the progress achieved so far is not quite satisfactory. It has been possible to get accepted for research only 10 out of 21 of the items considered as requiring immediate attention for research. Of the various institutions in India approached with a request that they may take up these investigations, only 8 have found it possible to take up any item. Since the large scale development of research in steel structural engineering is an essential requirement for placing the steel industry in India on a sound footing, thought should be given as to how far the present position can be improved. This need is all the greater, since a very large expansion in steel production and consumption is planned during the Second Five Year Plan and thereafter.

10.8.1 The steel structural engineering and the welding sections of the research laboratories in India require to be strengthened in order to enable to meet the country's immediate demand for expansion of experimental research in these fields.

11. Structure and Metal Division Council (SMDC)

11.1 The considerable amount of work done under the Steel Economy Programme of the ISI, has high-lighted the need and advantage of co-ordinating the production-and-use aspects in the standardization of metals. This has led to the setting up of the Structural and Metal Division Council (SMDC) of the ISI. This new Division Council which was inaugurated on 26th October 1956, with Sir Jehangir Ghandy as Chairman will hereafter deal with the metallurgical, structural and other use aspects of metals and connected subjects.

12. Technical Assistance

12.1. The services of Messrs Ramseyer and Miller, Inc., Iron and Steel Industry Consultants, New York, were made available by the United

States Technical Co-operation Mission in India, to assist the steel economy work of the ISI from early 1954. This first agreement with these Consultants, was for a period of two years from 4th February 1954. Arrangements were completed to continue their services for an additional period of one year up to February, 1957, with provision for further extension of one year up to February, 1958. In addition to the consultative service, made available from the New York Office of the Consulting Engineers and selected specialists in the United States, a resident engineer of the Consultants has been posted at Delhi and is co-operating in the day-to-day work of the ISI Directorate on the Steel Economy Programme.

ANNEXURE I

(*Clause 1.2*)

Composition of Structural Steel Sectional Committee (BDC 7)

Chairman	
Sir Jehangir Ghandy	Director-in-Charge, Tata Iron & Steel Co. Ltd., Jamshedpur
Shri P.H. Kutar (*Alternate Chairman*)	Technical Director, Tata Iron & Steel Co. Ltd., Jamshedpur
Members	
Shri N. Padmanabha Ayyar	Ministry of Iron and Steel, New Delhi
Shri K.F. Antia (Up to 22-2-56)	The Concrete Association of India, Bombay
Shri N.C. Bagchi Shri M.K. Haldar (*Alternate*) (Up to 6-9-56)	Government Test House, Calcutta
Shri S.L. Bazaz Shri P.C. Poonen (*Alternate*)	Roads Wing, Ministry of Transport
Shri H.M. Crowe	Durgapur Steel Mills
Dr. Ing. W.E. Krebs (Up to 30-3-55)	Tata Iron & Steel Co. Ltd., Jamshedpur
Shri S. Das Gupta (From 31-3-55 onwards) Mr. H. Hodgkinson (*Alternate*)	
Shri D.S. Desai (Up to 12-7-56)	Braithwaite, Burn & Jessop Construction Co. Ltd., Calcutta.
Shri D.M. Sen (From 12-7-56 onward)	
Shri D.S. Desai	(*i*) Institution of Engineers (India), Calcutta and (*ii*) Indian Roads Congress, New Delhi.

(*Contd.*)

Shri M.P. Nagarsheth (*Alternate*)	Indian Roads Congress, New Delhi
Director	Central Building Research Institute (CSIR), Roorkee
Shri R.N. Dutt	Iron & Steel Controller, Calcutta
Shri Jangbir Singh (Up to 6-4-55)	Ministry of Commerce and Industry (Development Wing)
Dr. B.D. Kalelkar (From 7-4-55 onwards)	
Shri C.J. Shah (*Alternate*) (Up to 6-4-55)	
Shri N. Krishnaswami (*Alternate*) (From 7-4-55 onwards)	
Shri H.K. Ramanujam (Up to 23-3-56)	Mysore Iron & Steel Works, Bhadravati
Shri T. Krishnappa (From 24-3-56 onwards)	
Shri A.S. Vallishayee (*Alternate*)	
Shri S.L. Kumar	Structural Steel Research Sub-committee (BDC 7 : 4)
Dr. A.K. Mallik	Indian Iron & Steel Co. Ltd., Burnpur
Shri T.J. Manickam	Indian Institute of Architects, Bombay
Mr. J.W. Miller	Indian Engineering Association, Calcutta
Mr. W.D. Holton (*Alternate*)	
Shri S.K. Mitra	Engineering Association of India, Calcutta
Shri A.K. Ghosh (*Alternate*) (Up to 4-5-55)	
Shri S. Srinivasan (*Alternate*) (From 5-5-55 onwards)	
Shri K.K. Nathani	Director General of Supplies & Disposals, (Inspection Wing), New Delhi.

(*Contd.*)

Mr. E.P. Nicolaides	J.C. Gamon Ltd., Bombay.
Dr. O.G.F. Paulssen	Palm Court, Queen Rd., Bombay-1
Mr. J.W. Rankin	Bridge and Roof Co. (India) Ltd., Calcutta
Shri A.L. Rao	Central Public Works Department, New Delhi
Representative	Bhillai Steel Mills
Col. G.S. Sihota	Engineers-in-Chief's Branch, Army Headquarters, New Delhi
Shri R.S. Mahendru (*Alternate*)	
Shri V. Venkataramayya (Up to 18-5-56)	Railway Board, New Delhi
Shri K.C. Sood (From 19-5-56 onwards)	
Shri Suku Sen Shri L.N. Misra (*Alternate*) Sri S.N. Srivastava (*2nd Alternate*)	Hindustan Steel Ltd., Calcutta
Shri K. Rama Varman	National Buildings Organisation, New Delhi.
Shri L.G. Toye (*Alternate*)	
Shri K. Vyasulu	Planning Commission, New Delhi
Dr. Lal C. Verman (*Ex-officio*)	Director, Indian Standards Institution

ANNEXURE II

(*Clause 3.3*)

Names of the Conveners of the Four Sub-committees and their Panels, Functioning under the Structural Steel Sectional Committee (BDC 7)

Sl. No.	*Convener*	*Sub-committee/Panel*
1.	Dr. O.G.F. Paulssen	Steel Sections Sub-committee, BDC 7 : 1
2.	Mr. A. M. Maddox	Panel for Specifications for Tubular Sections (BDC 7 : 1 : 1)
3.	Dr. O.G.F. Paulssen	Panel for Finalizing Standards for Hot Rolled Beam and Channel Sections (BDC 7 : 1 : 2)
4.	Shri M.S. Doshi	Panel for investigating Possibilities of Standardization of Piling Sections in India (BDC 7 : 1 : 3)
5.	Shri O.S. Murty	Panel for Preparing Reports on the activities of the Sub-committee BDC 7 : 1 (BDC 7 : 1 : 4)
6.	Shri V. Venkataramayya (Up to 19.5.56) Shri K.C. Sood (From 20.5.56 onwards)	Structural Codes and Design Sub-committee (BDC 7 : 2)
7.	Dr. O.G.F. Paulssen	Panel for Code of Practice for Use of Light Gauge Sections (BDC 7 : 2 : 1)
8.	Shri V. Venugopalan	Panel for Code of Practice for Transmission Towers and Radio Masts (BDC 7 : 2 : 2)
9.	Mr. A.H. Mitchell	Panel for Code of Practice for Crane Structures (BDC 7 : 2 : 3)
10.	Shri D.S. Desai	Panel for Code of Practice for Use of Steel in Storage Tanks (BDC 7 : 2 : 4)

(*Contd.*)

11.	Col. P.R. Kumar	Panel for Code of Practice for Use of Steel in Temporary Constructions (BDC 7 : 2 : 5)
12.	Shri V. Vekataramayya (Up to 19.5.56) Shri K.C. Sood (From 20.5.56)	Panel for Structural Handbooks (BDC 7 : 2 : 6)
13.	A.M. Maddox	Panel for Design Codes and Typical Designs for Tubular Sections (BDC 7 : 2 : 7)
14.	Shri D.S. Desai	Welding Sub-committee (BDC 7 : 3)
15.	Shri B.N. Bose	Panel for Welding Design Codes (BDC 7 : 3 : 1)
16.	Shri R.G. Bhatwadekar	Panel for Welding Procedure and Inspection (BDC 7 : 3 : 2)
17.	Mr. T.R. Shields	Panel for Training and Testing of Operators and Safety and Health Requirements in Welding (BDC 7 : 3 : 3)
18.	Shri A.M. Kapadia	Panel for Welding in Pipe Lines (BDC 7 : 3 : 4)
19.	Shri H.N. Ghosal	Panel for Resistance Seam and Spot Welding (BDC 7 : 3 : 5)
20.	Mr. T.R. Shields	Panel for Handbooks for Welding Operators and Inspectors (BDC 7 : 3 : 6)
21.	Shri B.R. Barua	Panel for Testing Methods (BDC 7 : 3 : 7)
22.	Mr. A.M. Maddox	Panel for Welding in Tubular Sections (BDC 7 : 3 : 8)
23.	Shri S.L. Kumar	Structural Steel Research Sub-committee (BDC 7 : 4)
24.	Shri S.L. Kumar	Panel for Proframes and Priorities in Research (BDC 7 : 4 : 1)

(Contd.

25.	Mr. E.H. Bucknall	Panel for Investigations Relating to Corrosion Protection of Light Gauge Steel Sections Used in Structures (BDC 7 : 4 : 2)
26.	Dr. S. Mackey	Panel for Investigations Relating to Standardization of Hot Rolled Steel Sections (BDC 7 : 4 : 3)
27.	Shri V. Cadambe	Panel for Investigations Relating to Improving the Shaping and Connections in Light Gauge Steel for Structural Use (BDC 7 : 4 : 4)
28.	Director, National Buildings Organization, New Delhi	Panel for Investigations on Floor Loads in Buildings (BDC 7 : 4 : 5)

ANNEXURE III

(*Clause 6.1*)

Progress of Work under the Steel Economy Programme (Up to 31st December 1956)

(*a*) Draft Standards Finalized for Publication

(*i*) Code of Practice for Use of Structural Steel in General Building Construction ;

(*ii*) Glossary of Terms Relating to Welding and Cutting of Metals ;

(*iii*) Scheme of Symbols for Welding ;

(*iv*) Specification for Covered Electrodes for Metal Arc Welding of Mild Steel ;

(*v*) Classification and Coding of Covered Electrodes for Metal Arc Welding of Mild Steel and of Low Alloy High Tensile Steels ;

(*vi*) Code of Practice for Use of Metal Arc Welding of General Construction in Mild Steel ;

(*vii*) Code of Practice for Training and Testing of Metal Arc Welders ;

(*viii*) Rolled Steel Beams ;

(*ix*) Rolled Steel Channels ;

(*x*) Rolled Steel Angles ;

(*xi*) Code of Practice for Safety and Health Requirements in Electric and Gas Welding and Cutting Operations ; and

(*xii*) Code of Practice for Resistance Spot Welding for Light Assemblies in Mild Steel.

(*b*) Draft Standards under Wide Circulation

(*i*) Rolled Steel Tee Bars ; and

(*ii*) Rolled Steel Bulb Angles

(*c*) Draft Standards under Preparation

(*i*) Specification for Cold Formed Light Gauge Steel Structural Sections ;

(*ii*) Specification for Tubular Sections ;

(*iii*) Rolled Steel Piling Sections ;

(*iv*) Special Steel Sections for Structural Use ;

(*v*) Code of Practice for Use of Cold Formed Light Gauge Steel Sections in Structures ;

(*vi*) Rules for the Design, Construction, Erection, Testing, Operation, Maintenance and Inspection of Cranes and Hoists ;

(*vii*) Code of Practice for Pressed Steel Tanks ;

(*viii*) Code of Practice for Design, Fabrication and Erection of Mild Steel Tanks for Storage of Oil ;

(*ix*) Code of Practice for Design Fabrication and Erection of Steel Tanks, Standpipes, Reservoirs and Elevated Tanks or Water Storage ;

(*x*) Code of Practice for Gas Storage Tanks ;

(*xi*) Code of Practice for Use of Steel Tubes in General Building Construction ;

(*xii*) Code of Practice for High Strength Bolting in Structures ;

(*xiii*) Code of Practice for Light Weight Open Web Steel Joist Construction ;

(*xiv*) Code of Practice for Use of Steel in Overhead Transmission Line Towers ;

(*xv*) Code of Practice for Use of Steel in Radio Masts ;

(*xvi*) Code of Practice for Use of Steel in Temporary Construction ;

(*xvii*) Code of Practice for Use of Welding in Weldments (Built up Sections for Use in Place of Steel Castings) ;

(*xviii*) Code of Practice for Use of Welding in Boilers ;

(*xix*) Code of Practice for Use of Gas Welding in Structural Work ;

(*xx*) Code of Practice for Use of Welding in Structures Subject to Dynamic Loading Bridges.

(*xxi*) Procedure Code for Electric Arc Welding ;

(*xxii*) Code of Practice for Inspection of Welds ;

(*Contd.*)

(*xxiii*) Code of Practice for Use of Welding in Pipelines ;

(*xxiv*) Code of Practice for Resistance Seam Welding for Light Gauge Sections ;

(*xxv*) Code of Practice for Use of Welding in Tubular Construction ;

(*xxvi*) Specification for Corrosion Protection of Light Gauge Construction ; and

(*xxvii*) Specification for Performance Tests for Protective Schemes Used in Corrosion Protection of Light Gauge Steel.

(*d*) **Handbooks under Preparation**

(*i*) Handbook of Properties of Structural Steel Sections ;

(*ii*) Handbook for Structural Engineers (Including Typical Designs and Drawings) ;

(*iii*) Handbook for Welders ;

(*iv*) Handbook for Welding Inspectors and Supervisors ; and

(*v*) Handbook for Welding Engineers, (Including Typical Designs and Drawings).

ANNEXURE IV

(*Clause 8.1*)

List of Items on Which Experimental Investigations Have Been Undertaken by Various Institutions in India

Sl. No.	*Problem*	*Organization/Laboratory*
1.	Effect of Cold Straightening, Cold Bending, Punching etc., on the Physical Properties of Structural Steel.	University of Roorkee, Roorkee
2.	Cold Forming of Strip Steel into Structural Shapes through Cold Rolling and Cold Pressing.	—do—
3.	Formulation of suitable specifications of Chemical and Physical Properties and Surface Finish for Strip Steel to be used in the manufacture of Cold-Formed Light Gauge Sections of Use in Steel Structures.	—do—
4.	Connecting Methods for Cold-Formed Sections—Effect of Welding, Bolting and Riveting on the Properties of the Cold-Formed Sections of Problem (2).	—do—
5.	Investigations to establish standard Welding Procedures with regard to Type of Electrodes, Preheating and Post Heating Methods etc, for different types of thicknesses of Structural Steel Produced in India.	—do—
6.	Investigations aimed at establishing improved methods of testing of Weld Test Specimens.	—do—
7.	Elastic Modulus of Steel between the limit of proportionality and yield stress.	—do—

(*Contd.*)

8.	Design of Rigid Steel Frames.	(*i*) University of Roorkee, Roorkee (*ii*) National Physical Laboratory, New Delhi.
9.	Investigations on Composite Encastre Concrete and Rail Steel Section.	Indian Institute of Technology, Khargpur
10.	Investigation on Steel Beams and Concrete Slab Combinations.	—do—
11.	Experimental Determination of the Length of Strut.	Indian Institute of Technology, Khargpur.
12.	Investigations on Rigid Frames by Photographic Methods.	College of Engineering, Anantpur
13.	Mechanical Behaviour of Stressed Structural Steels.	Indian Institute of Science, Bangalore
14.	Establishing Improved Methods of Testing of Weld Test Specimens,	Railway Testing and Research Sub-centre, Chittaranjan
15.	Investigations to establish Properties of Weldable Quality Mild Steels and High Tensile Steels for Production in India.	—do—
16.	Investigations to establish Standard Welding Procedure with regard to Type of Electrodes, Pre-heating and Post Heating Methods, etc. for different types and thicknesses of Structural Steels produced in India.	—do—

Appendix II

Technical Information Series **4**

USE OF DEFORMED REINFORCING BARS IN CONCRETE

NATIONAL BUILDINGS ORGANISATION

A deformed reinforcing bar is a steel bar the surface of which is provided with lugs or protrusions to inhibit the longitudinal movement of the bar relative to concrete which surrounds it and which conforms to the Tentative Specifications for Bars for Concrete Reinforcement (A. S. T. M. Designation : A 15, A 16 and A 160.)

The sizes of deformed bars are, in some countries like the U. S. A., designated by bar numbers which are based on the number of eighths of an inch included in the nominal diameter of the bars. The nominal diameter of a deformed bar is equal to the diameter of a plain bar having the same weight per unit length as the deformed bar. For example, a deformed bar weighing 0.688 lbs. per ft. is designated as No. 4 and has a nominal diameter of 0.500″ (of cross sectional area 0.20 sq. in. and perimeter 1.571 in.).

Requirements

The American standard specification* gives the requirements and other details of the deformations on the bar. Briefly stated, they are :—

(1) Deformations shall be spaced substantially uniformly along the bar. The deformations on the opposite sides of a bar shall be similar in shape and size.

(2) The deformations shall be placed with respect to the axis of the bar to certain specified minimum included angles.

(3) The average spacing or distance between deformations on each side of the bar shall not exceed 7/10th of the nominal diameter of the bar.

(4) The gap between extreme ends of deformations or the width of the longitudinal rib in which the deformations end shall not exceed specified limits.

(5) The average height of deformations shall be not less than 4 to 5 per cent of the nominal diameter of the bar depending on the diameter of the bar. The specified dimensions for a typical bar of designation No. 4 are given in the table that follows :

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*A. S. T. M. 305-537.

Dimensional Requirements for Deformed Steel Bars for Concrete Reinforcement.

Deformed Bar Designation Number	Deformation requirements in inches.		
	Maximum Average Spacing	Minimum Height	Maximum Gap (Chord of 12½ per cent of nominal Perimeter),
4	0.350	0.020	0.191

Tests

Tests were conducted at the instance of National Bureau of Standards, Washington, D. C., U. S. A. to compare the resistance to slip in concrete (bond) of deformed bars when tested in beams and in pull-out tests on specimens to secure information on the effect of size of bars, type of deformations and the concrete strengths on the bond. Tests were made with two sets of beams, one cast with the reinforcement on the bottom of the test beam and the other on the top. Three lengths of embedment namely 8″, 12″ and 16″ and several types of bars were tried. Out of these the tests carried out on $\frac{7}{8}''$ diameter plain bars and $\frac{7}{8}''$ nominal diameter deformed bar similar in shape to the one manufactured in this country are considered in this note.

Three types of concrete were used depending upon their 28 days strength in pounds per square inch designated as 6,000, 3,500 and 2,000 concretes. The tests were made both on R. C. C. beams 8″×18″×78″ and (for pull out tests) in concrete specimens 8″×9″×8″, 8″×9″×12″ and 8″×9″×16″ corresponding to the three lengths of embedment as specified above.

All beams tested generally failed in bond. Pull-out specimens failed by the splitting of concrete except in the case of the plain bar.

Some of the results of these tests in so far as the two types of bars under discussion are concerned, are indicated in *Figures 1 to 6*. These curves have been reduced to refer to the 3,500 concrete. The general trend for all the three grades were, however, similar.

Some authorities consider that the allowable stresses for bond for use in designs are obtained by applying a suitable factor of safety on the average of bond stresses developed in tests at a slip of 0.01" at the loaded end and 0.005 inch at the free end. *Figure 9* represents the bond stresses at loaded end slip of 0.01" and free end slip of 0.005 inch and the average of the two as determined by beam and pull-out tests of the bottom and top cast bars.*

Advantages

The advantages of deformed bars when used in R. C. C. lie in that the deformations assist in forming a series of narrow closely spaced cracks instead of a few wide ones. It also helps in providing better and special anchorages to assist in offsetting diagonal tension. It will be seen from the earlier paras in this note that the investigations carried out have shown that not only the deformations in the bars affect the bond but the position of the bar in the specimen itself was also a criterion. For example bars cast horizontally on top of the specimen were less effective in bonding than those at the bottom. *Figures 10 and 11* give the pattern of the recorded stresses as measured along the lengths of hooked bars. *Figure 11* indicates that with properly deformed bars, hooks are redundant, but with plain bars considerable stress is picked up by the hook.

The advantages of correctly deformed bars as substantiated by numerous tests include :—

(1) greatly improved bond permitting safe working stresses in bond up to 10 per cent of ultimate compressive strength.

(2) an accurate crack control since the high and close projections and deformations prevent the formation of a few large cracks and make the concrete and steel work more closely as a unit.

(3) a possible increase in tensile stresses due to more positive bonding and a continuous bonding all along the bars instead of a special anchorage at the end as in the case of a plain hooked bar.

The use of such bars will thus result in better structures through the closely spaced but narrower cracks in tension concrete. This is of particular advantage in tanks and similar liquid retaining structures and also renders much less unsightly the conditions at highly-stressed negative movement zones around supports.

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*Based on this study A. S. T. M. Standard 305-47T for deformation of steel bars for concrete reinforcement was formulated. This was amended in 1949 and was later on revised in 1953. The provisions in the revised Code have been indicated earlier in this note.

Bond Stress

The American Concrete Institute's Building Code for reinforced concrete (A. C. I. 318-56) permits increased bond stresses in the case of deformed bars conforming to the A. S. T. M. specifications mentioned earlier. An extract from this Code relating to bond stress from the table 305(a) : Allowable unit stresses in concrete, is reproduced here.

Description	Allowable unit stresses						
	For any strength of concrete in accordance with Section 302 $n=\frac{30,000}{fc'}$	Maximum value	For strength of concrete shown below.				
			fc'= 2000 n=15	fc'= 2500 n=12	fc'= 3000 n=12	fc'= 3750 n=8	fc'= 5000 n=6
Bond : *u*							
Deformed bars (as defined in Section 104)							
Top bars* ... u	0.07 fc'	245	140	175	210	245	245
In two-way footing u (except top bars)	0.08 fc'	280	160	200	240	280	280
All others ... u	0.10 fc'	350	200	250	300	350	350
Plain bars (as defined in Section 104) (must be hooked).							
Top bars ... u	0.03 fc'	105	60	75	90	105	105
In two way footing u (except top bars)	0.036 fc'	126	72	90	108	126	126
All others ... u	0.045 fc'	158	90	113	135	158	158

*Top bars in reference to bond, are horizontal bars so placed that more than 12 in. of concrete is cast in the member below the bar.

It would appear from this that for deformed bars a bond stress of about twice what is permitted in the case of a plain bar of the same diameter is allowable. Consequently the lappages and anchorage required become modified as compared with plain bars. Some of the relevant provisions that affect these factors are summarised below.

(1) In slab beams and girders, splices of the reinforcement at points of maximum stresses shall be avoided. All splices used shall be welded, lapped or otherwise fully developed and shall transfer the entire stress from bar to bar without exceeding *the allowable bond and shear stress given in the table* The minimum overlap for a lapped splice shall be 24 diameters but not less than 12″.

(It will be clear from this provision that a saving of about 20 diameters is possible in most cases if deformed bars are used in place of plain bars. It will also be noted that in the case of deformed bars there is no advantage to be derived by hooking the ends and as such the amount of steel usually used for hooking (14 d) is saved by using the deformed bars).

(2) In the case of stirrups in deep beams the specifications permit that the stirrups may be anchored in such a way that they embed above or below the mid-depth of the beam on the compression side, a distance sufficient to develop the stress to which the bar will be subjected at a bond stress not to exceed 0.045 fc. for plain bars or 0.10 fc. for deformed bars, subject to a minimum of 24 diameters.

(3) The anchorage requirements of tensile negative reinforcement are also favourable for deformed bars. The tensile reinforcement shall be adequately anchored by bond hooks or by mechanical means. In the case of deformed bars the hooks are not required subject to the minimum leg of 12 d beyond the point at which it is no longer needed to resist the stress. In the case of deformed bars with larger permissible bond stresses the lengths of embedment at the ends of beams, at points of inflection etc., will thus be very much less than in the case of plain bars.

Saving in Steel

It will be seen from the foregoing that the use of deformed bars* as reinforcement in concrete will lead to considerable saving in steel. It may be roughly estimated that such a saving will not be less than 7 per cent in the case of ordinary building constructions and may be much more in the case of long spans where the lengths of reinforcement commercially available are such that a large number of splices are usually found necessary.

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*Deformed bars are now being manufactured in India by the Tata Iron & Steel Company. Tests on these bars are in hand at the Central Building Research Institute Roorkee. The results of these tests will be published by that Institute and the National Buildings Organisation in due course.

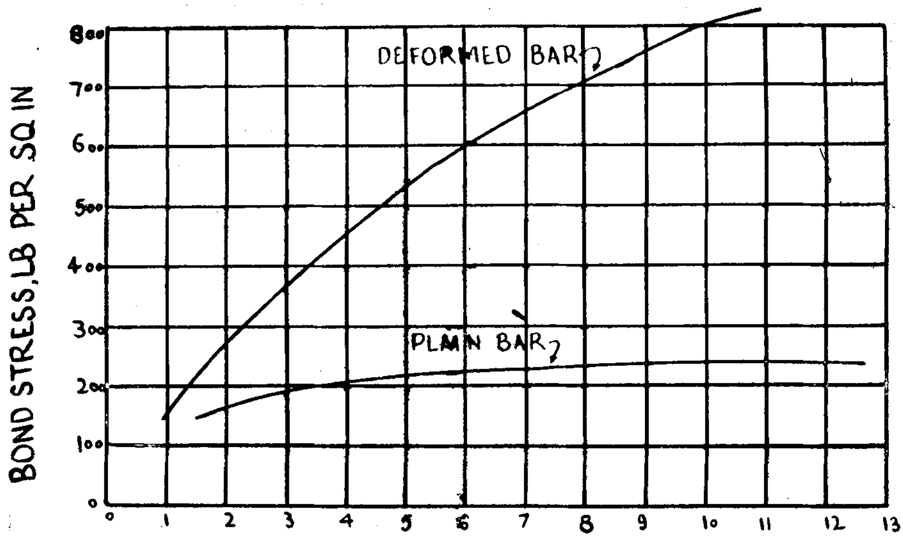


FIG 1

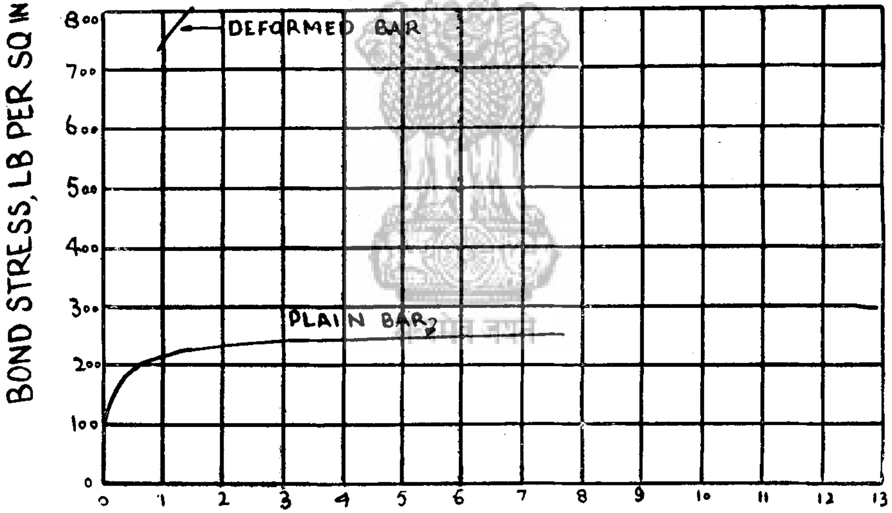


FIG 2.

FIG 1. BOND SLIP CURVES FOR 7/8-IN. BOTTOM BARS IN BEAMS SLIP MEASURED AT LOADED END.

FIG 2. BOND-SLIP CURVES FOR 7/8 IN. BOTTOM BARS IN BEAMS SLIP MEASURED AT FREE END

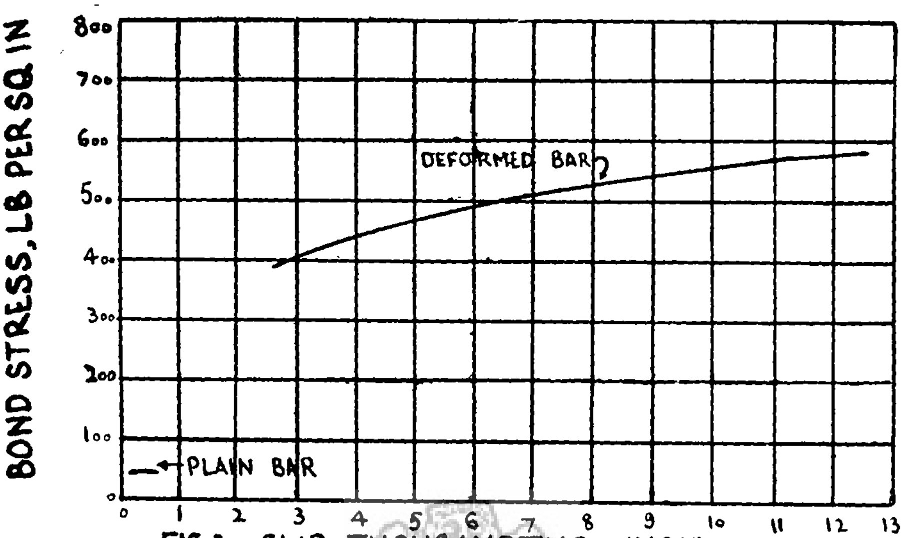


FIG 3. SLIP, THOUSANDTHS INCH

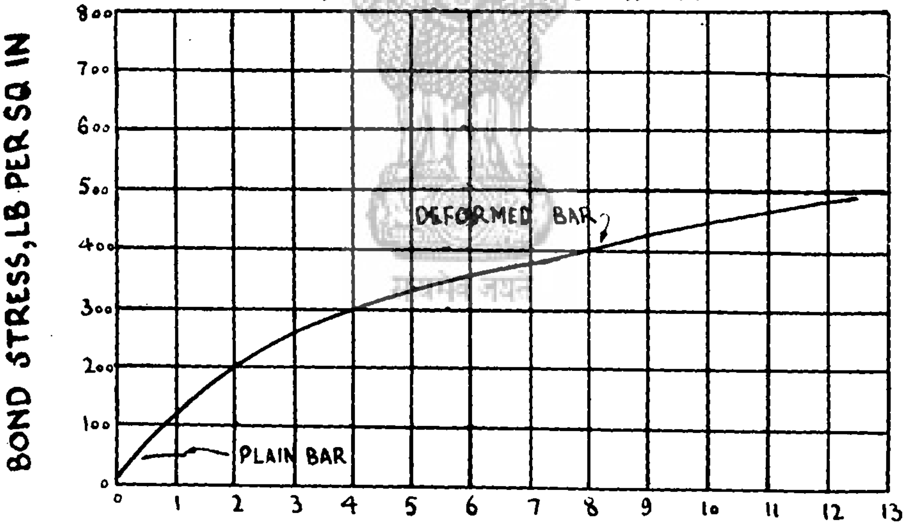


FIG 4 SLIP, THOUSANDTHS INCH

FIG 3. BOND-SLIP CURVES FOR 7/8-IN. TOP BARS IN BEAMS, SLIP MEASURED AT LOADEDE END.

FIG 4. BOND-SLIP CURVES FOR 7/8-IN TOP BARS IN BEAMS, SLIP MEASURED AT FREE END

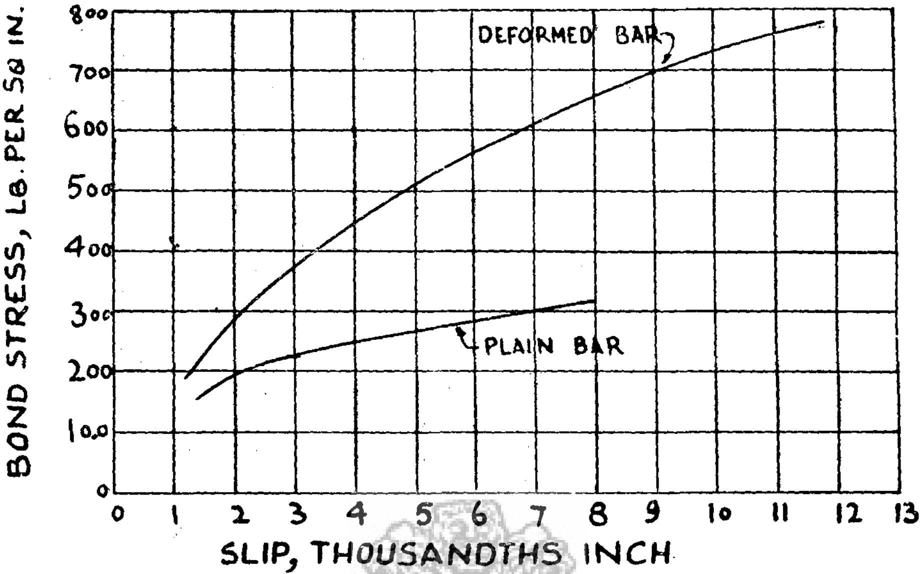


FIG. 5 BOND-SLIP CURVES FOR 7/8-IN. BOTTOM BARS IN PULL-OUTS, SLIP MEASURED AT LOADED END

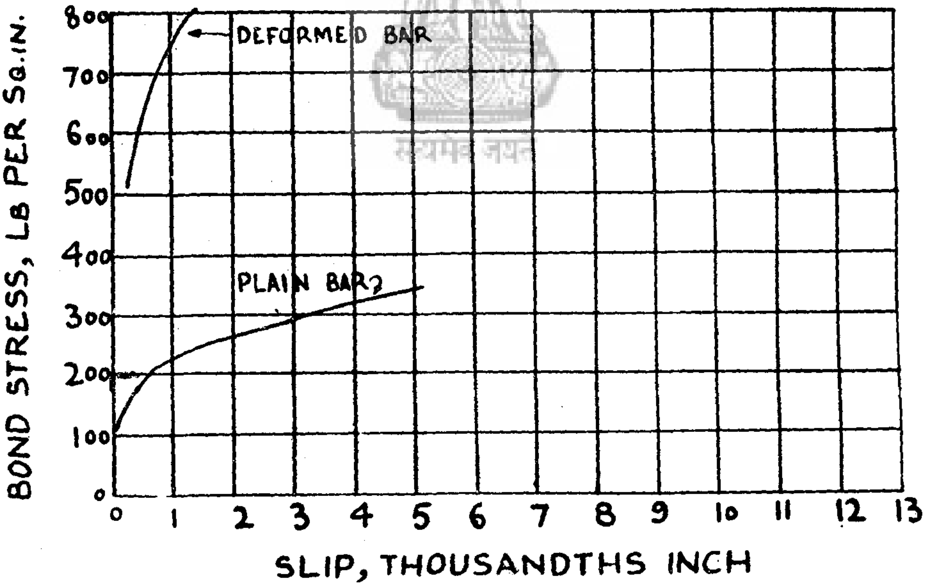


FIG. 6 BOND-SLIP CURVES FOR 7/8-IN. BOTTOM BARS IN PULL-OUTS, SLIP MEASURED AT FREE END.

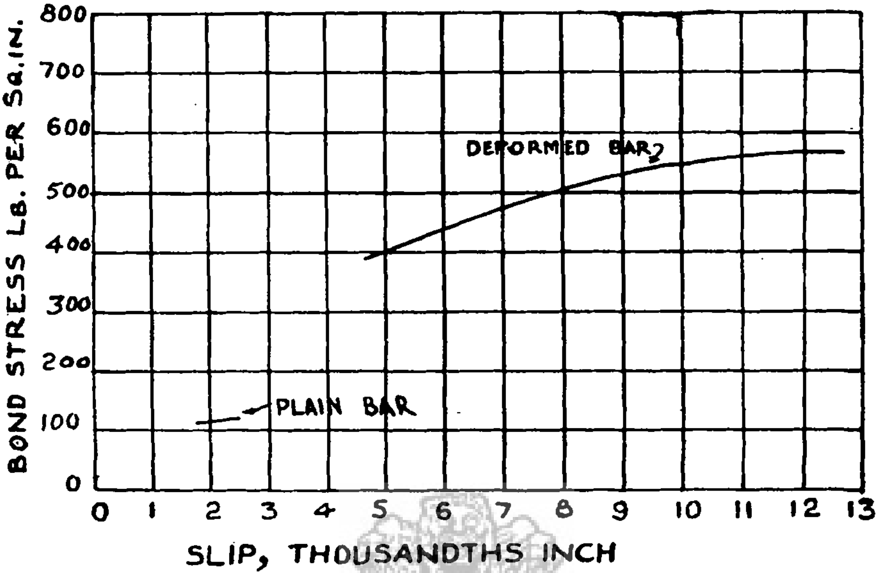


FIG 7. BOND-SLIP CURVES FOR 7/8-IN. TOP BARS IN PULL-OUTS, SLIP MEASURED AT LOADED END

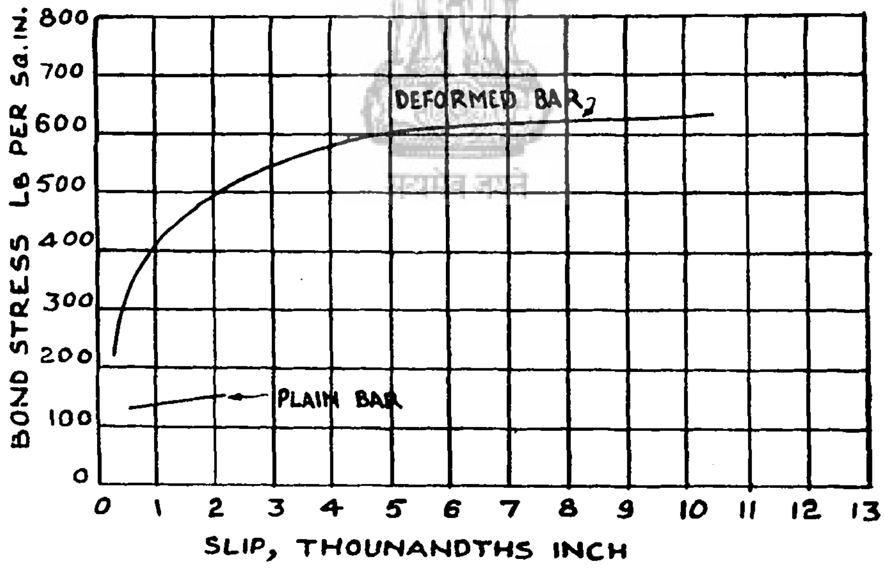
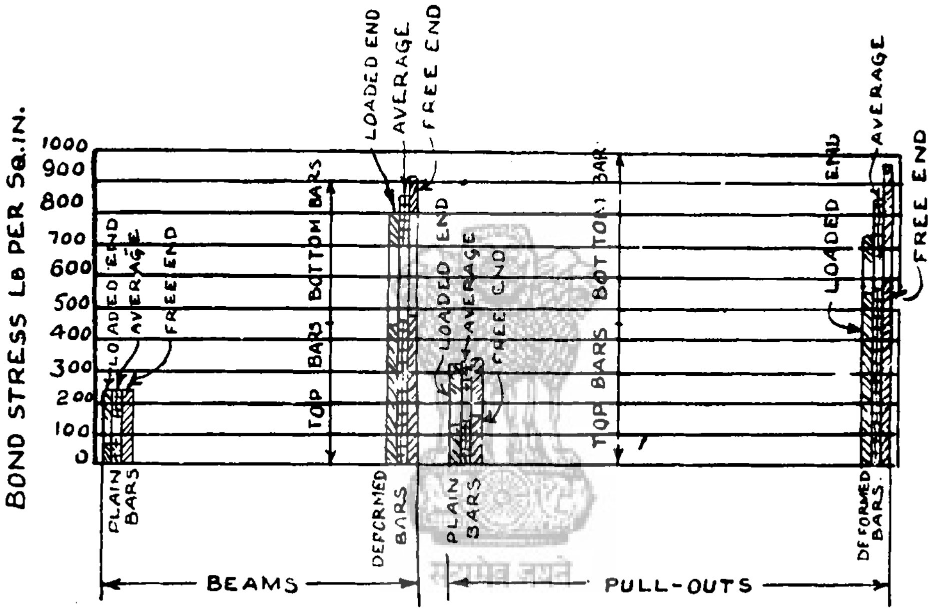


FIG 8. BOND-SLIP CURVES FOR 7/8-IN. TOP BARS IN PULL-OUTS, SLIP MEASURED AT FREE END.



BOND STRESSES FOR EACH 7/8 IN. BAR AT LOADED END SLIP OF 0.01 IN. FREE END SLIP OF 0.005 IN. AVERAGE OF THE TWO FOR BOTTOM AND TOP BARS IN BEAMS AND PULL-OUTS.

FIG. 9.

SOURCE : Fig 1 to 9 taken from Journal of the American Concrete Institute, Nov.-Dec., 1937 Vol. 34, pp. 145-164.

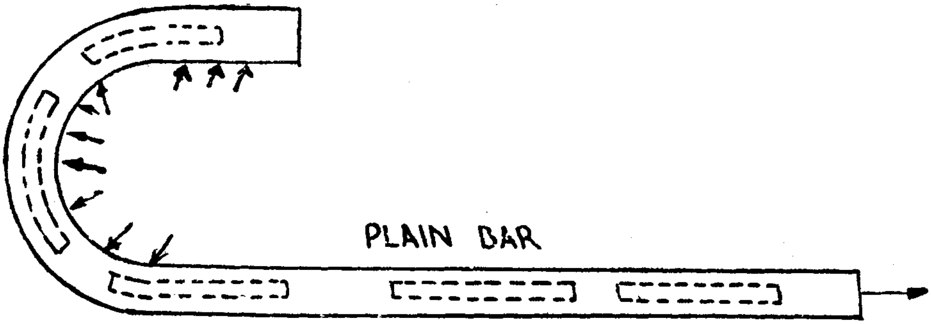


FIG 10.

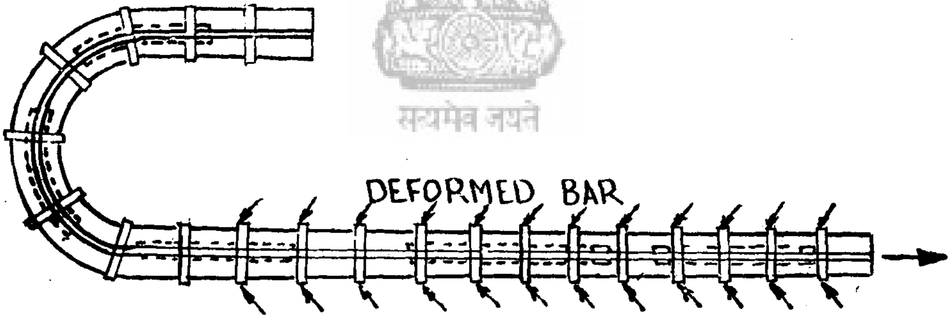


FIG 11.

RECORDED STRAIN IN HOOKED BARS.

SOURCE : Journal of the American Concrete Institute, May, 1950 pp. 678.